Advanced Microwave Precipitation Radiometer (AMPR) Observations during OLYMPEX/RADEX

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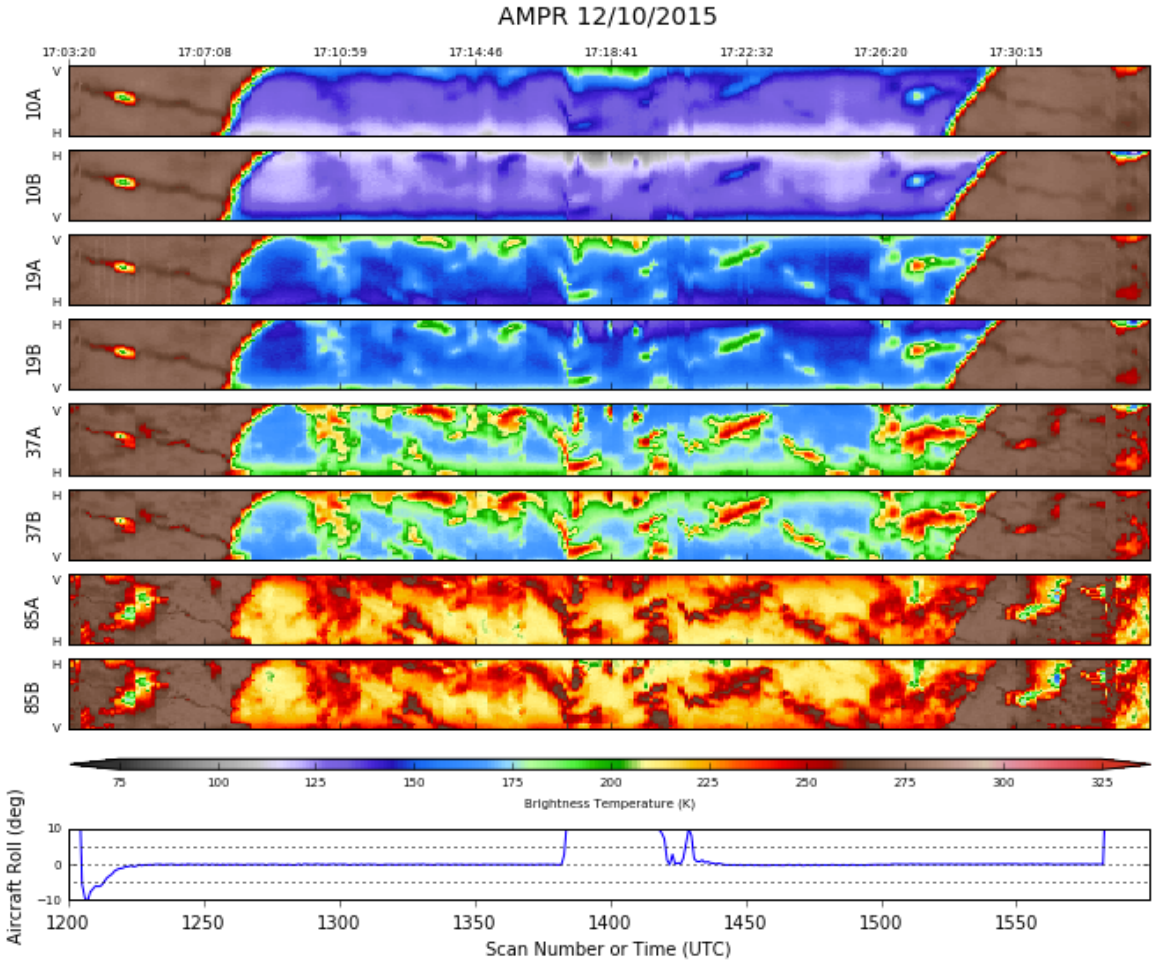

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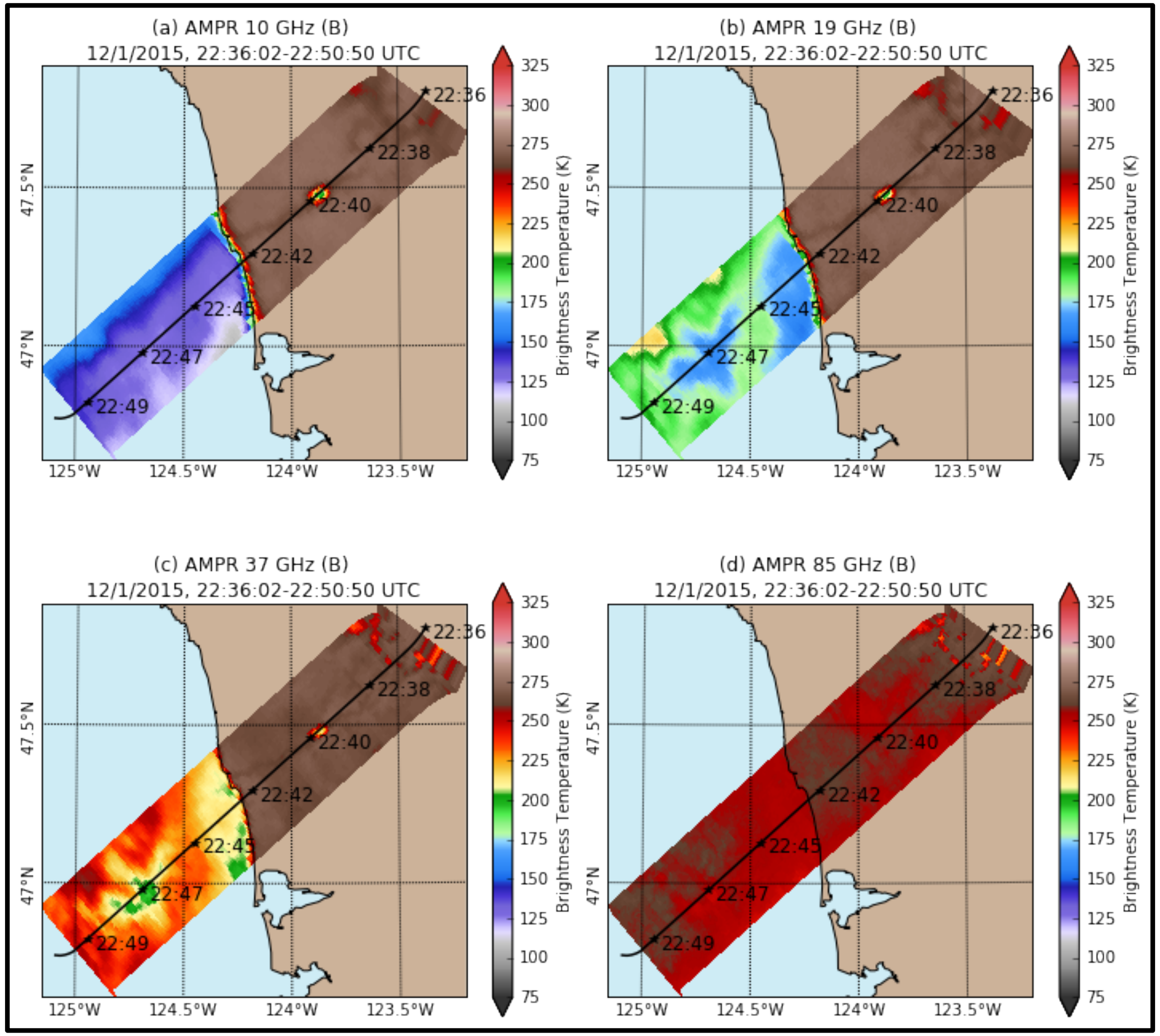
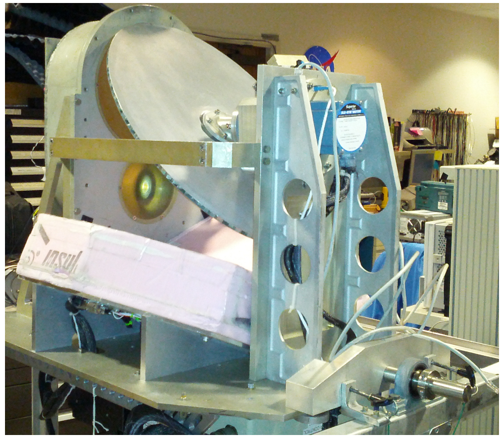
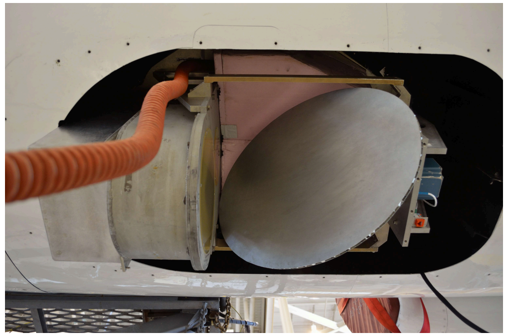


AMPR Instrument Summary

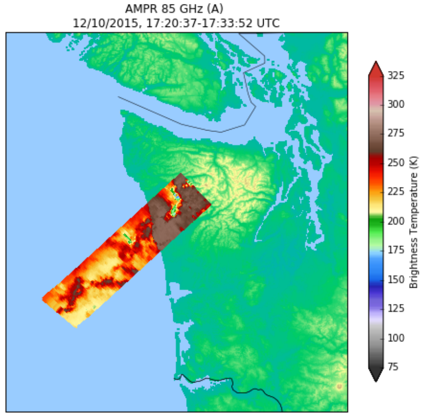
In the lab



In the plane



Over the storm



Instrument/Model name / PI:

AMPR (Advanced Microwave Precipitation Radiometer)

T. Lang, NASA MSFC

Data/Measurements/Retrievals:

- Passive microwave radiometer – Retrieve surface emission, cloud liquid water, precipitation rate, water vapor, ice scattering, and more
- Four frequencies - 10.7, 19.35, 37.1, 85.5 GHz, with 2 variable polarization channels apiece (Channel A: V -> H and Channel B: H -> V)
- Cross-track scanning, polarization state varies according to scan angle, H & V deconvolution possible

Previous deployments: IPHEx, MC3E, CAMEX 1-4, TCSP, TC4, KWAJEX, TRMM/LBA, TOGA-COARE, FIRE-III, TEFLUN-A

Notable publications:

Leppert II, K. D., and D. J. Cecil, 2015: Signatures of hydrometeor species from airborne passive microwave data for frequencies 10–183 GHz. *J. Appl. Meteor. Climatol.*, **54**, 1313–1334.

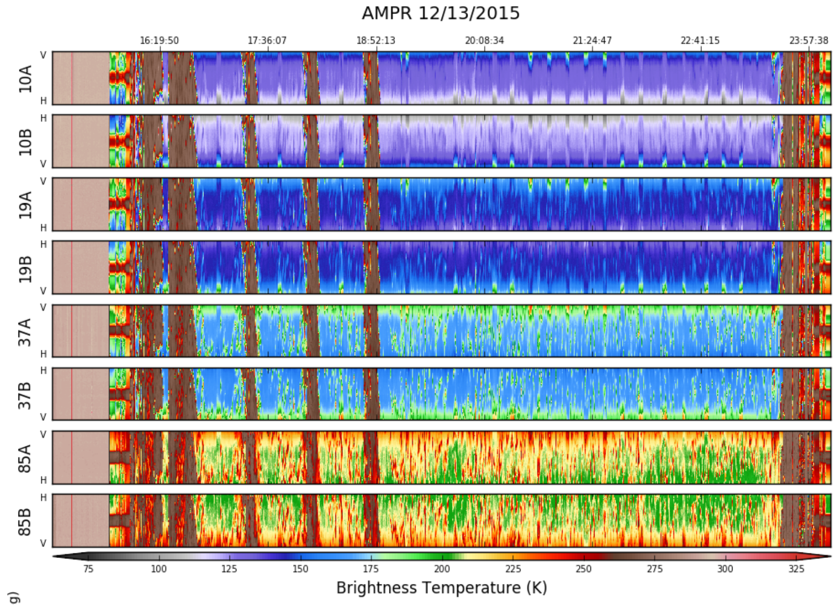
Hood, R. E., D. J. Cecil, F. J. LaFontaine, R. J. Blakeslee, D. M. Mach, G. M. Heymsfield, F. D. Marks Jr., E. J. Zipser, and M. Goodman, 2006: Classification of tropical oceanic precipitation using high-altitude aircraft microwave and electric field measurements. *J. Atmos. Sci.*, **63**, 218–233.

Spencer, R. W., R. E. Hood, F. J. Lafontaine, E. A. Smith, R. Platt, J. Galliano, V. L. Griffin, and E. Lobl, 1994: High-resolution imaging of rain systems with the advanced microwave precipitation radiometer. *J. Atmos. Oceanic Technol.*, **11**, 849–857.

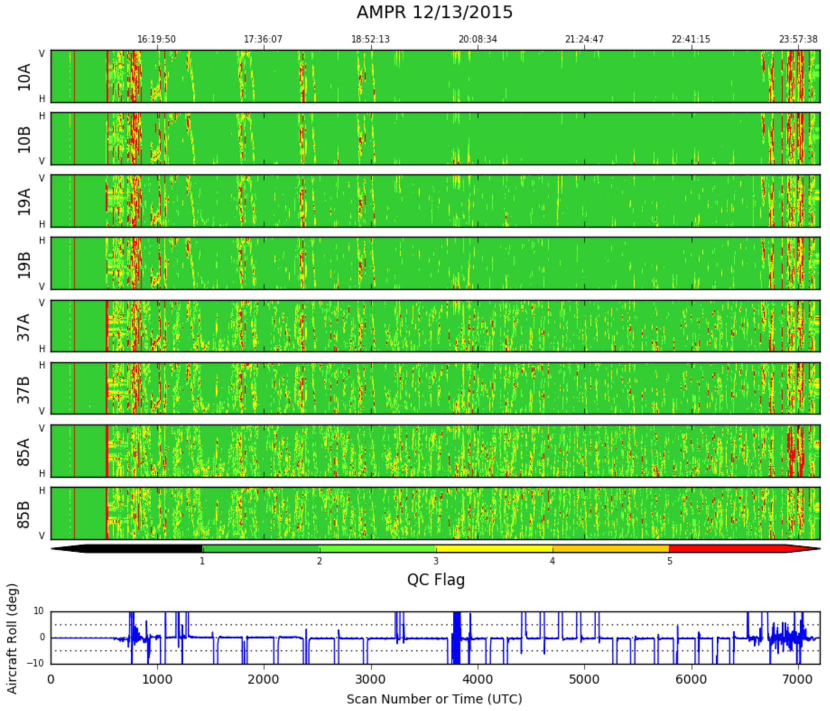
AMPR OLYMPEX Dataset Overview

- Geolocated Channel A and B mixed-pol TBs available in netCDF files from each day, wherever fine OLYMPEX data are found
- QC flags & land/water fraction available – Use as rough guide for data quality; see README
- Software to read/display/analyze here: https://github.com/nasa/PyAMPR
- 19 GHz unavailable 12/3-12/8
- 85 GHz (A) occasionally elevated noise floor masked open water signal (affected portions of 11/18, 12/4, 12/8)

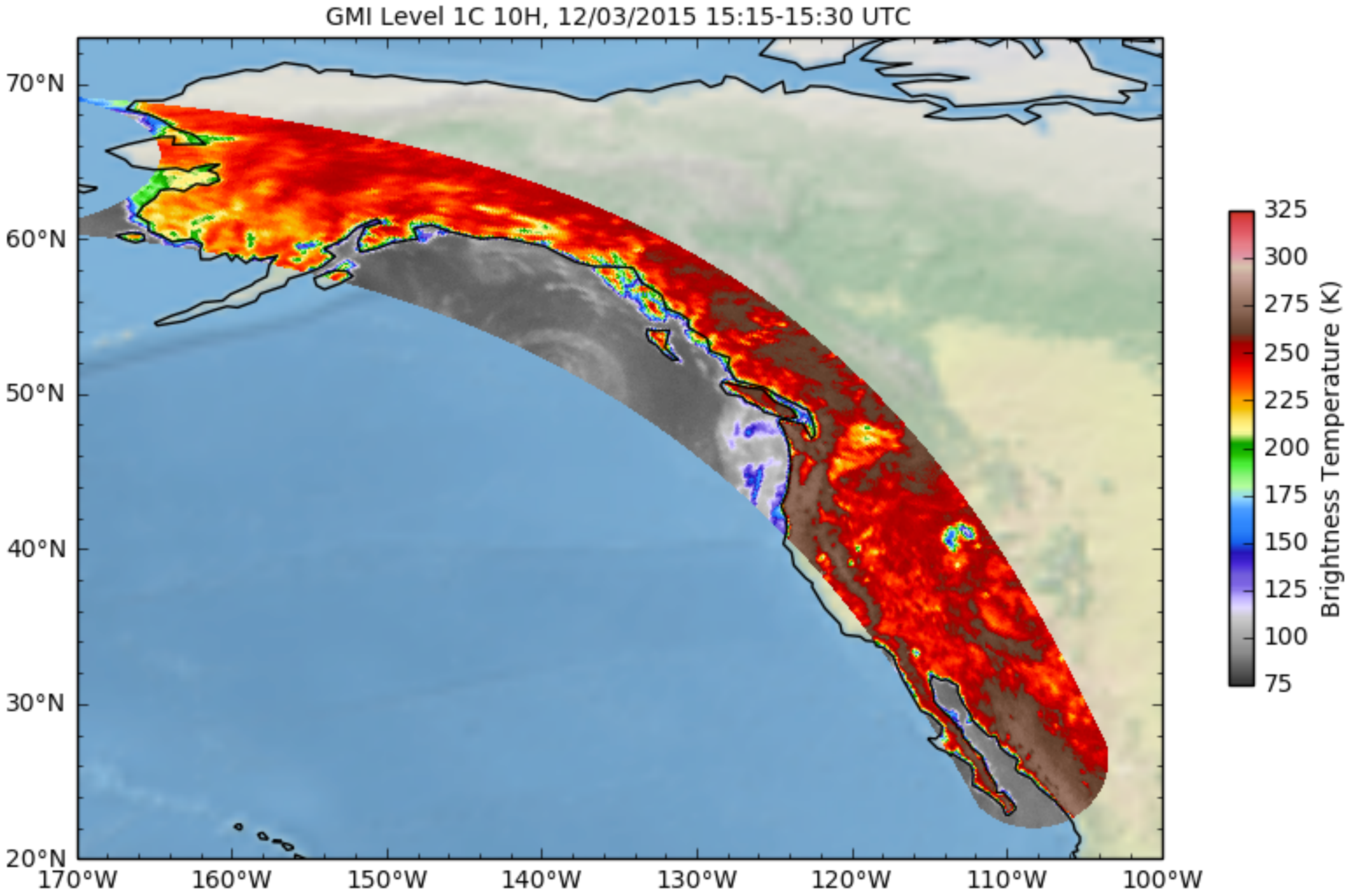
TBs



QC Flags



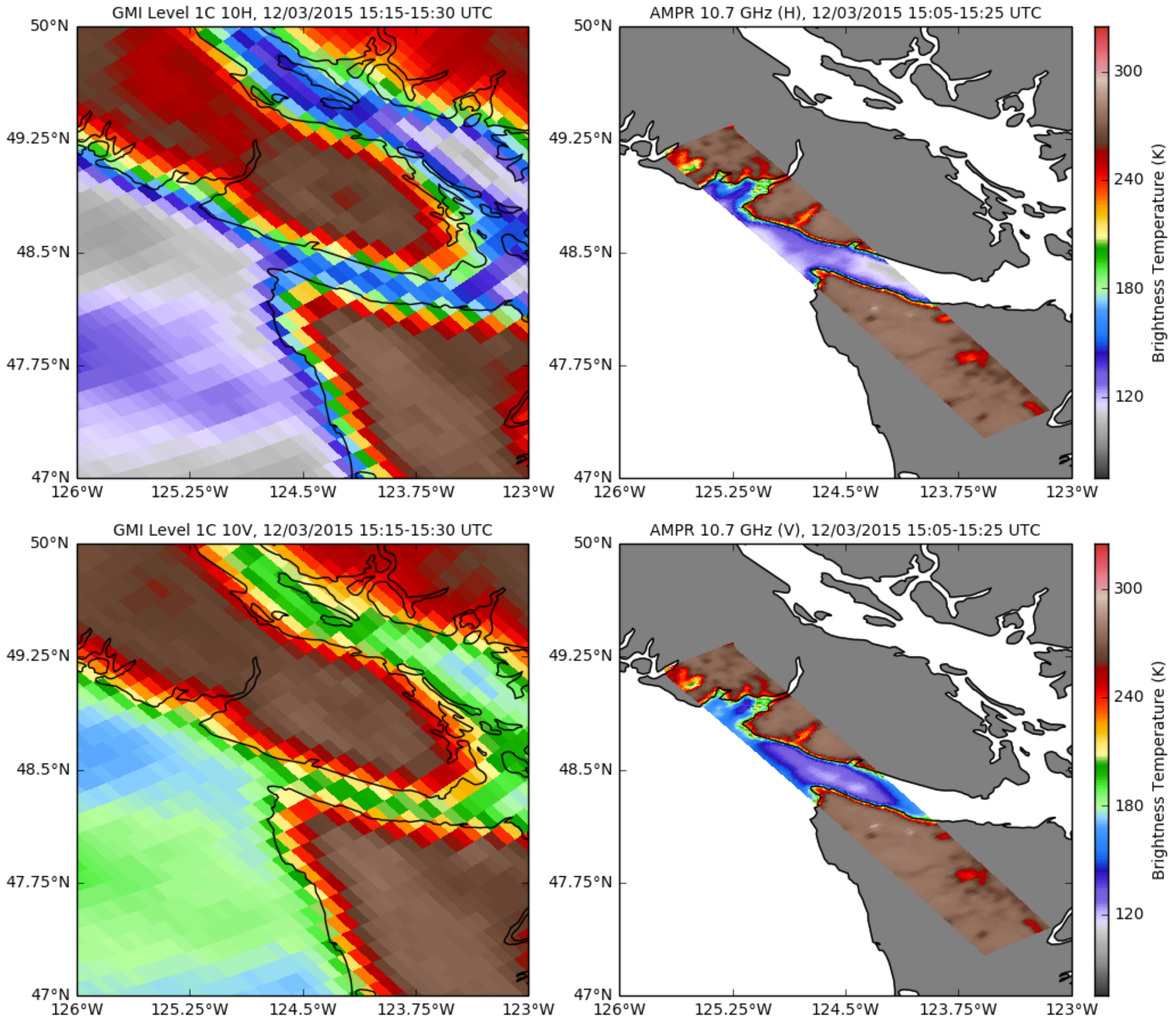
AMPR vs. GMI for 12/3 Underflight



Note: These are polarization-deconvolved AMPR data!

GMI 10H

AMPR 10H

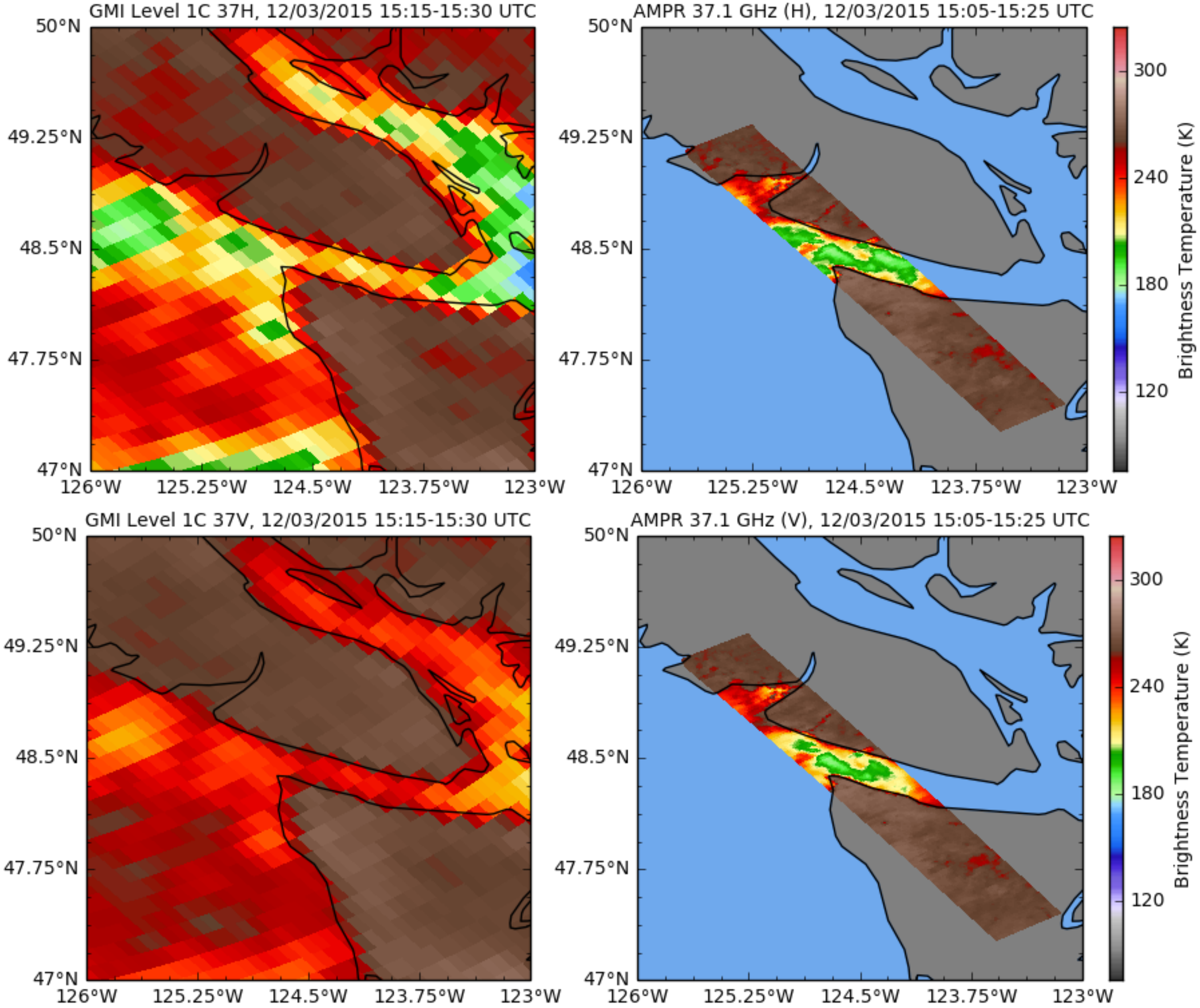


GMI 10V

AMPR 10V

GMI 37H

AMPR 37H



GMI 37V

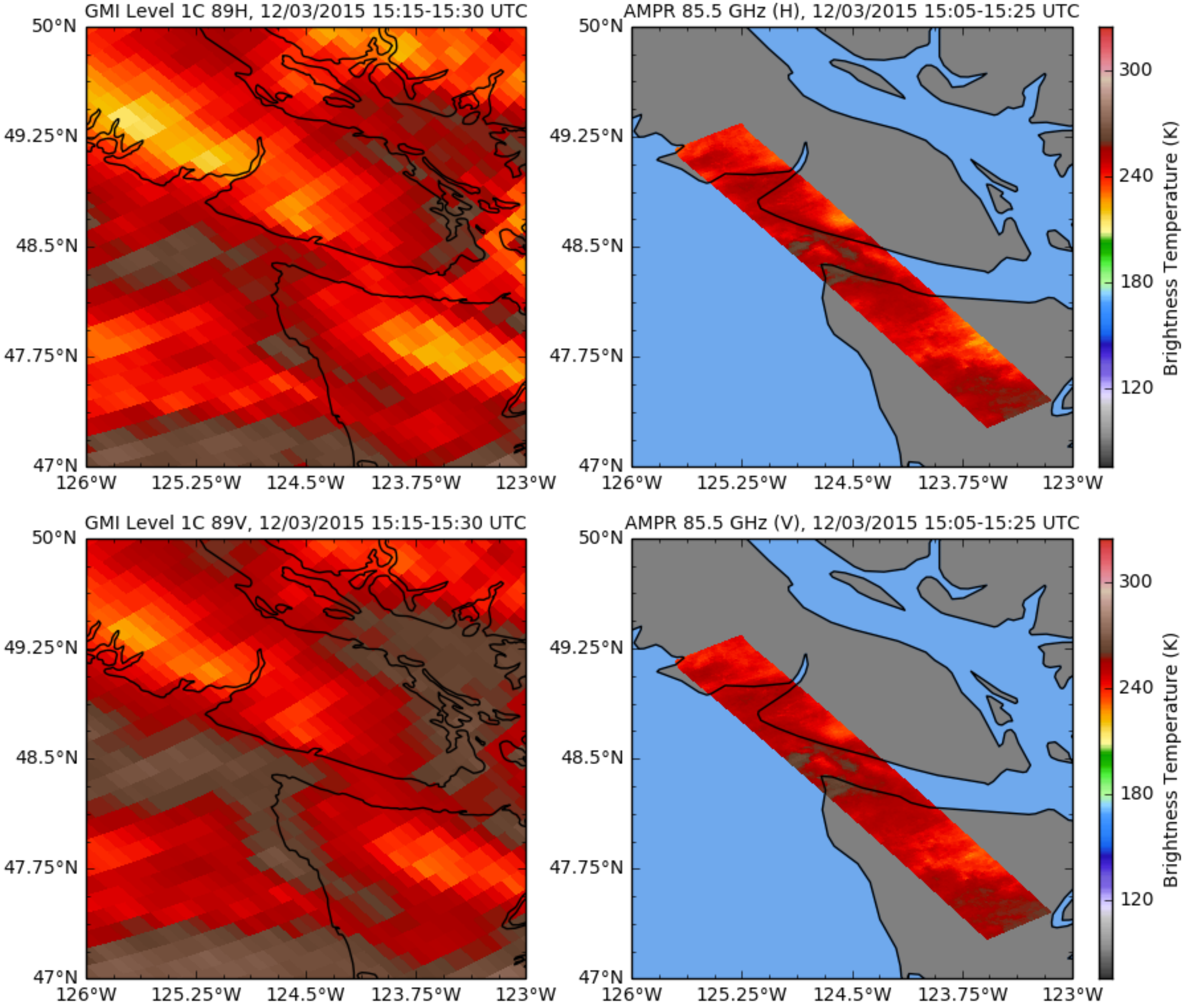
AMPR 37V

GMI 89H

AMPR 85H

GMI 89V

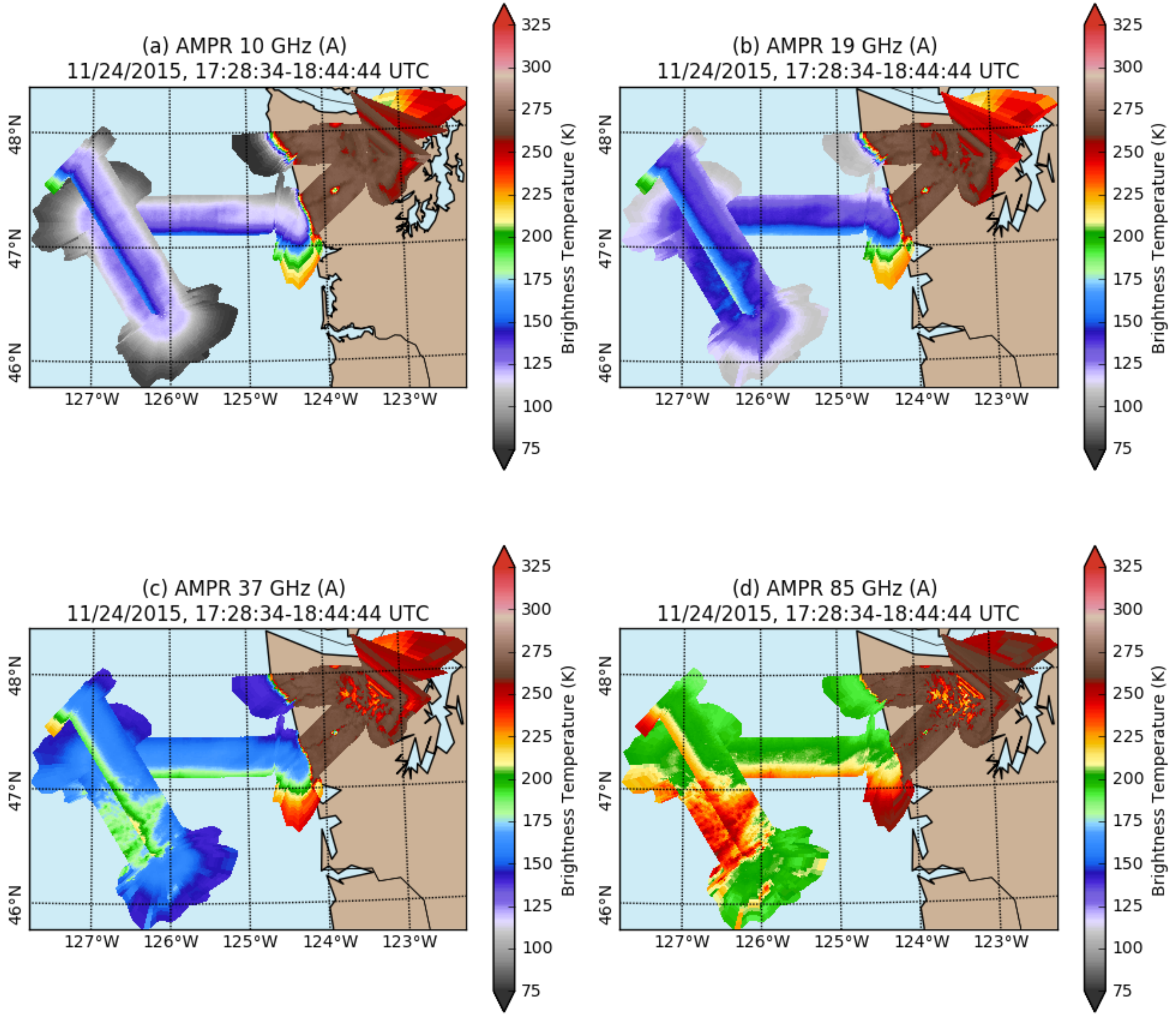
AMPR 85V



Major Takeaways from 12/3 Underflight

- AMPR resolves complex TB structure within Strait of Juan de Fuca, GMI affected by land/ocean FOV mixing
- Over land, away from coasts, there is broad agreement (taking into account resolution differences) – although AMPR senses apparent mountain snow fields at 10/37 GHz
- No AMPR 19 GHz this day – Gunn oscillator failure (was repaired later in project)

AMPR 11/24 Geophysical Retrievals



Multi-Linear Regression Model(s)

- Model for Columnar Water Vapor (V in mm):

$$V\,(mm) = a_0 + a_1*T_{B10v} + a_2*T_{B10h} + a_3*\ln(290-T_{B19v}) + a_4*\ln(290-T_{B19h}) + a_5*\ln(290-T_{B37v}) + a_6*\ln(290-T_{B37h}) \quad (1)$$

- Model for Columnar Cloud Liquid Water (L in mm):

$$L\,(mm) = a_0 + a_1*\ln(290-T_{B19v}) + a_2*\ln(290-T_{B19h}) + a_3*\ln(295-T_{B85v}) + a_4*\ln(295-T_{B85h}) \quad (2)$$

- Model for Surface Wind Speed (WS in m/s):

$$WS\,(m/s) = a_0 + a_1*T_{B10v} + a_2*T_{B10h} + a_3*\ln(290-T_{B19v}) + a_4*\ln(290-T_{B19h}) + a_5*T^2_{B10v} + a_6*T^2_{B10h} + a_7*T_{B10v}*T_{B10h} + a_8*SST \quad (3)$$

Where, $T_{Bnv,h}$ = Measured T_B for n GHz v,h-polarization channels

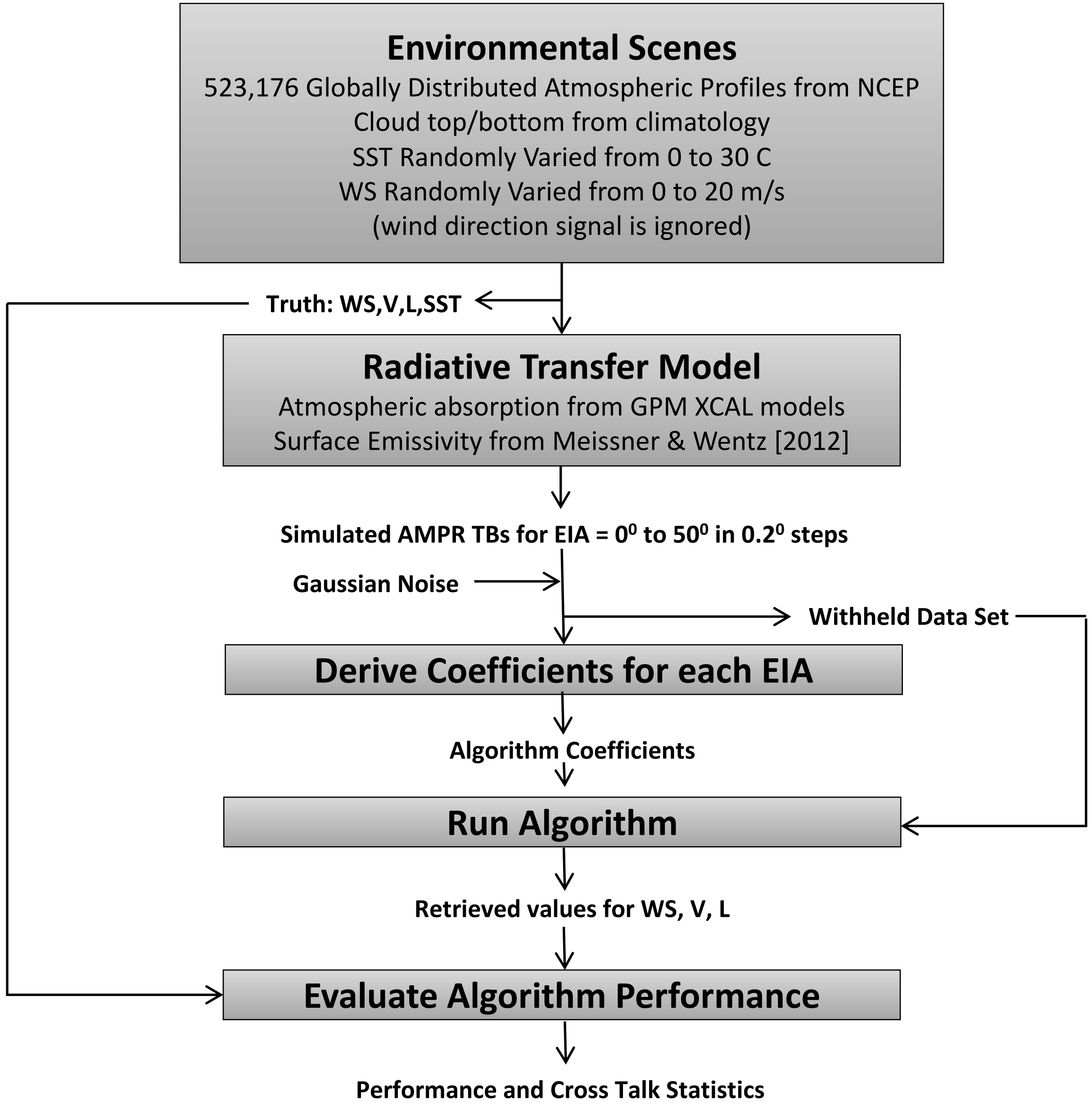
SST = Sea Surface Temperature in Kelvin (a priori value needed)

a_n coefficients are polynomial functions of the incidence angle*

The WS retrieval is further improved by generating 'a' coefficients for different range of wind speeds, e.g. WS<=3, WS>3<=7, WS>7<=12 & WS>12 .

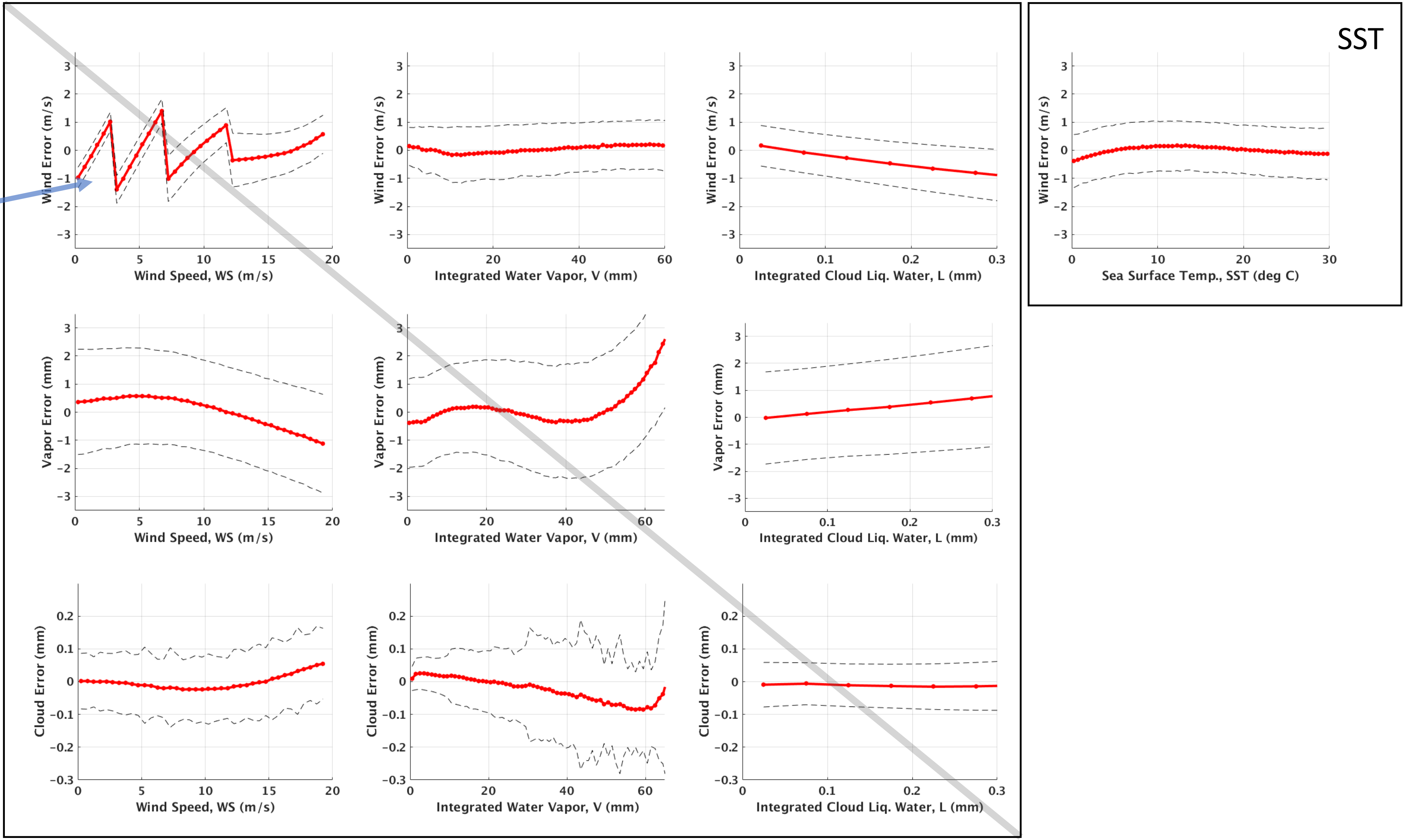
(*AMPR is a cross-track scanner and the observation incidence angle varies between 0^0 to 45^0)

Coefficient Derivation & Testing



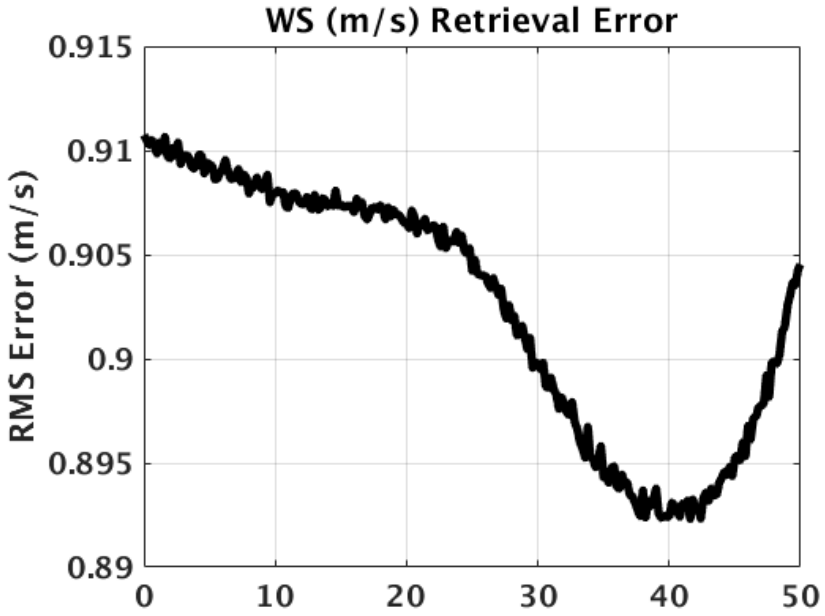
Retrieval and Cross-Talk Error

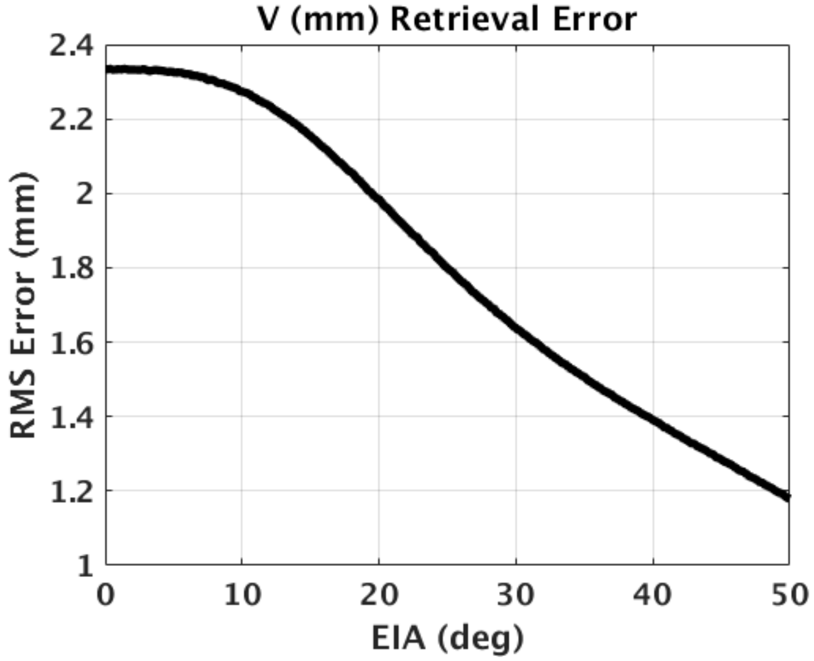
Multi-step wind retrieval to reduce low bias in weak winds

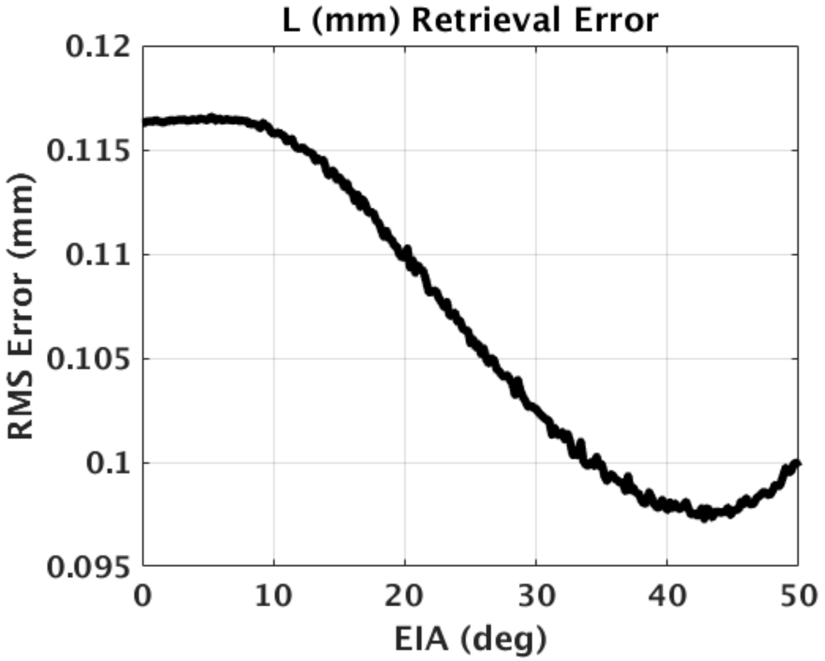


Errors are averaged over all Earth Incidence Angles (EIA) between 0 to 50 deg

RMS Retrieval Error vs. Earth Incidence Angle (EIA)

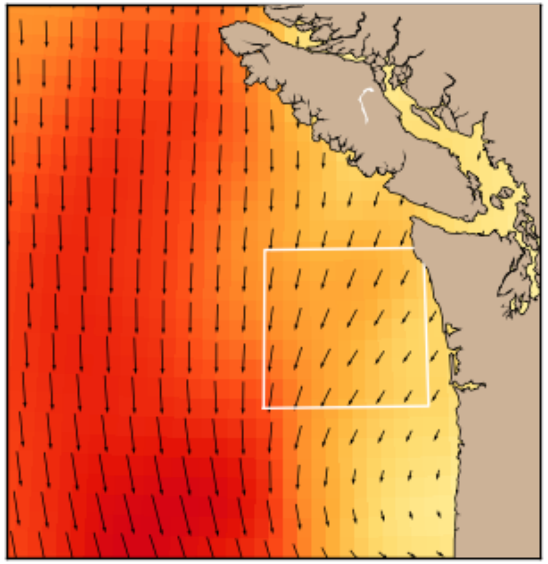


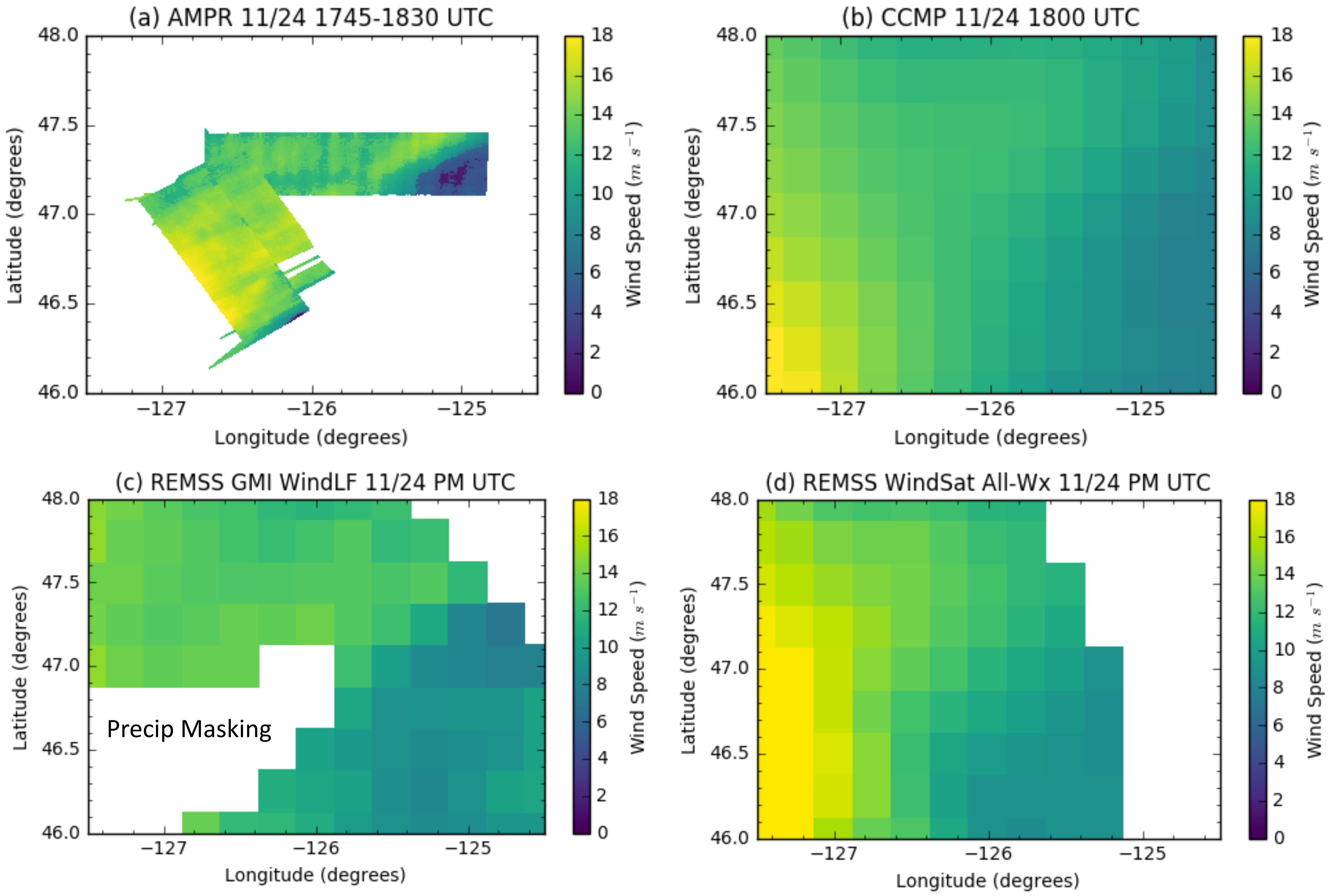




EIA average RMS Retrieval Error	
WS (m/s)	0.9
V (mm)	1.85
L (mm)	0.11

AMPR vs. REMSS Wind Products

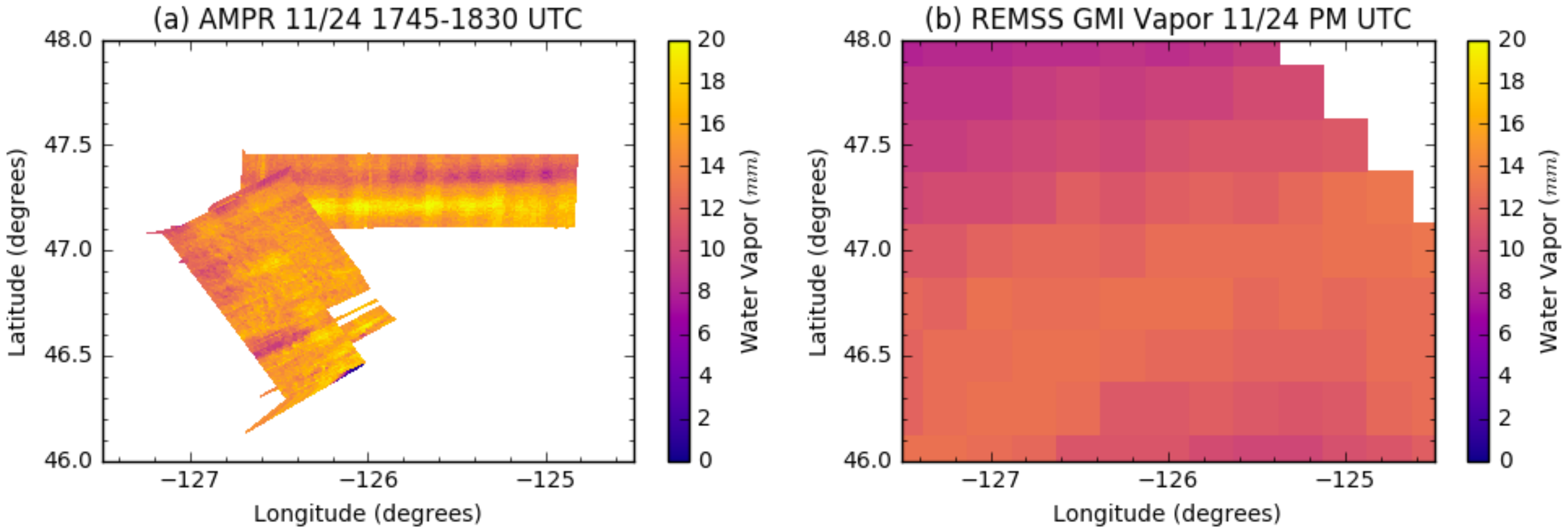




- Slantwise gradient captured by AMPR
- Range of domain wind speeds captured
- Possible precip influence at 19 GHz

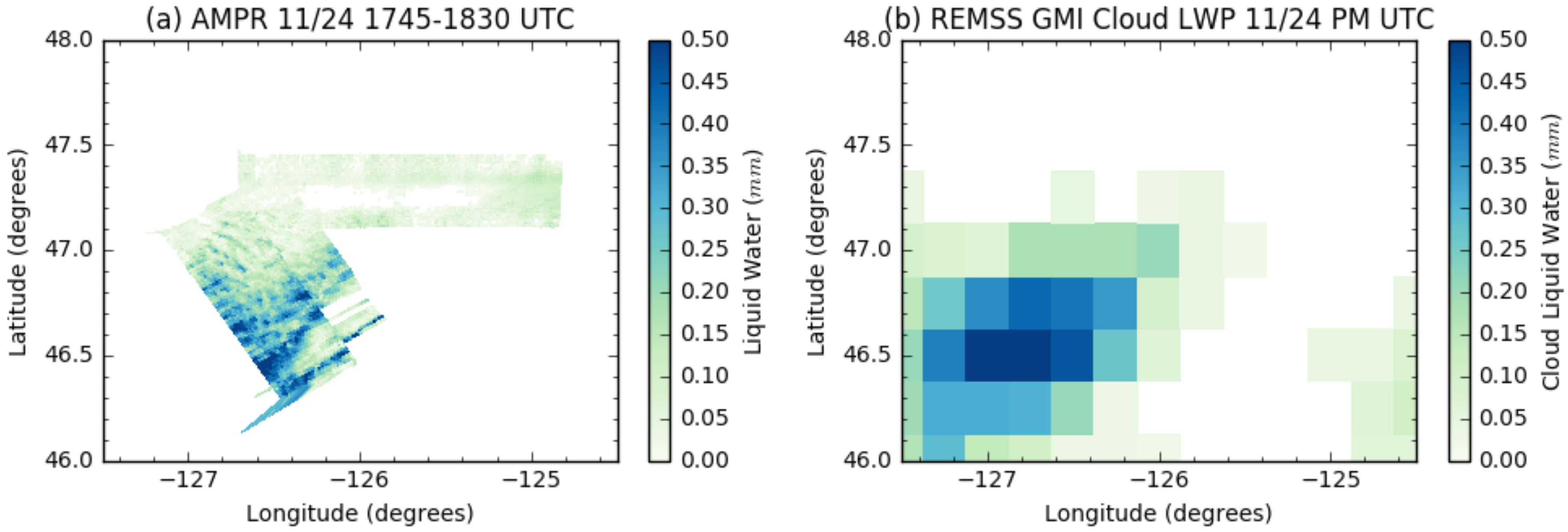
Water Vapor

- AMPR High Bias?
- Scan Angle Dependence?
- Work to be done here



Cloud Water

- Range of values in domain captured
- Good location correspondence



Major Takeaways from 11/24 Geophysical Retrievals

- Empirical model for retrievals developed and applied to deconvolved H & V polarized observations

- Wind speed and cloud liquid water show promising results and demonstrate AMPR's potential resolution advantages

- Water vapor model requires more development to resolve observed biases

Ongoing and Future Work

- Currently upgrading AMPR data system (was delayed by OLYMPEX/ORACLES crush) – Will mitigate obsolescence risk and facilitate greater scanning agility
- Currently characterizing NEDT stability, pointing angle uncertainty, and receiver nonlinearity in lab – Will improve TB and geophysical retrievals
- Examining other IPHEx, OLYMPEX, and ORACLES cases – Need collaborators!

QUESTIONS?

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